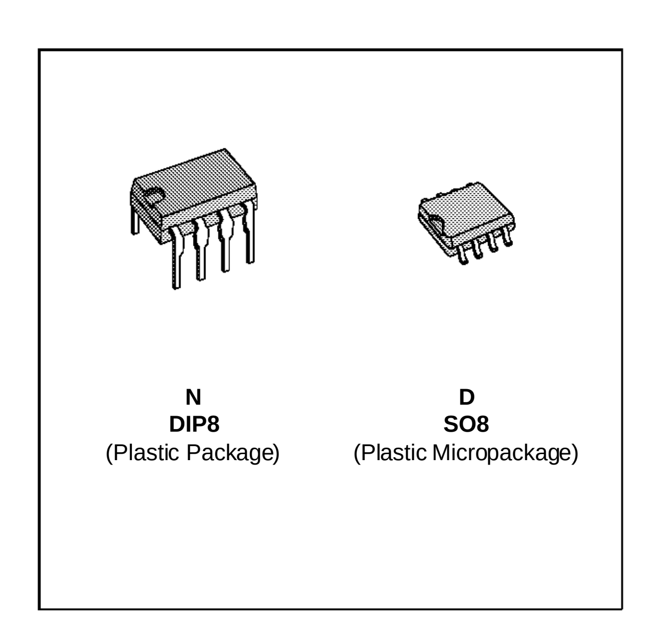




LOW POWER DUAL OPERATIONAL AMPLIFIERS

- INTERNALLY FREQUENCY COMPENSATED
- LARGE DC VOLTAGE GAIN : 100dB
- WIDE BANDWIDTH (unity gain) : 1.1MHz (temperature compensated)
- VERY LOW SUPPLY CURRENT/AMPLI (500µA) - ESSENTIALLY INDEPENDENT OF SUPPLY VOLTAGE
- LOW INPUT BIAS CURRENT : 20nA (temperature compensated)
- LOW INPUT OFFSET CURRENT : 2nA
- INPUT COMMON-MODE VOLTAGE RANGE INCLUDES GROUND
- DIFFERENTIAL INPUT VOLTAGE RANGE EQUAL TO THE POWER SUPPLY VOLTAGE
- LARGE OUTPUT VOLTAGE SWING 0V TO (V_{CC} – 1.5V)



ORDER CODES

Part Number	Temperature Range	Package	
		N	D
LM2904	–40°C, +125°C	•	•
Example : LM2904D			

2904-01.TBL

DESCRIPTION

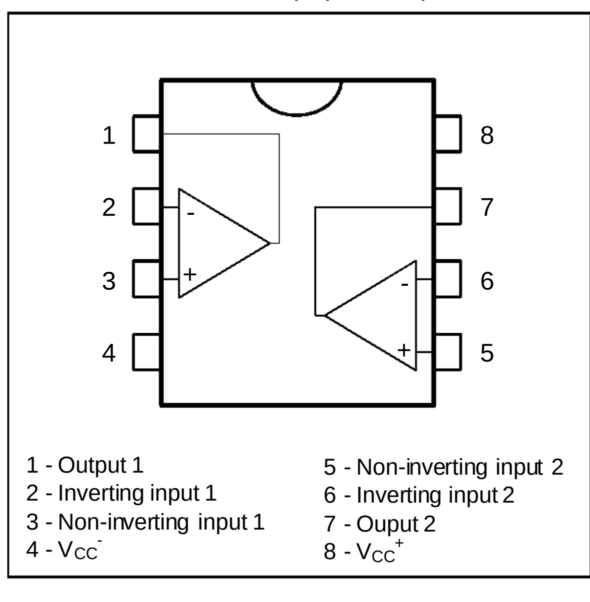
This circuit consists of two independent, high gain, internally frequency compensated which were designed specifically to operate from a single power supply over a wide range of voltages. The low power supply drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, dc gain blocks and all the conventional op-amp circuits which now can be more easily implemented in single power supply systems. For example, these circuits can be directly operated off the standard + 5V power supply voltage which is used in logic systems and will easily provide the required interface electronics without requiring any additional power supply.

In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.

The gain-bandwidth product is temperature compensated.

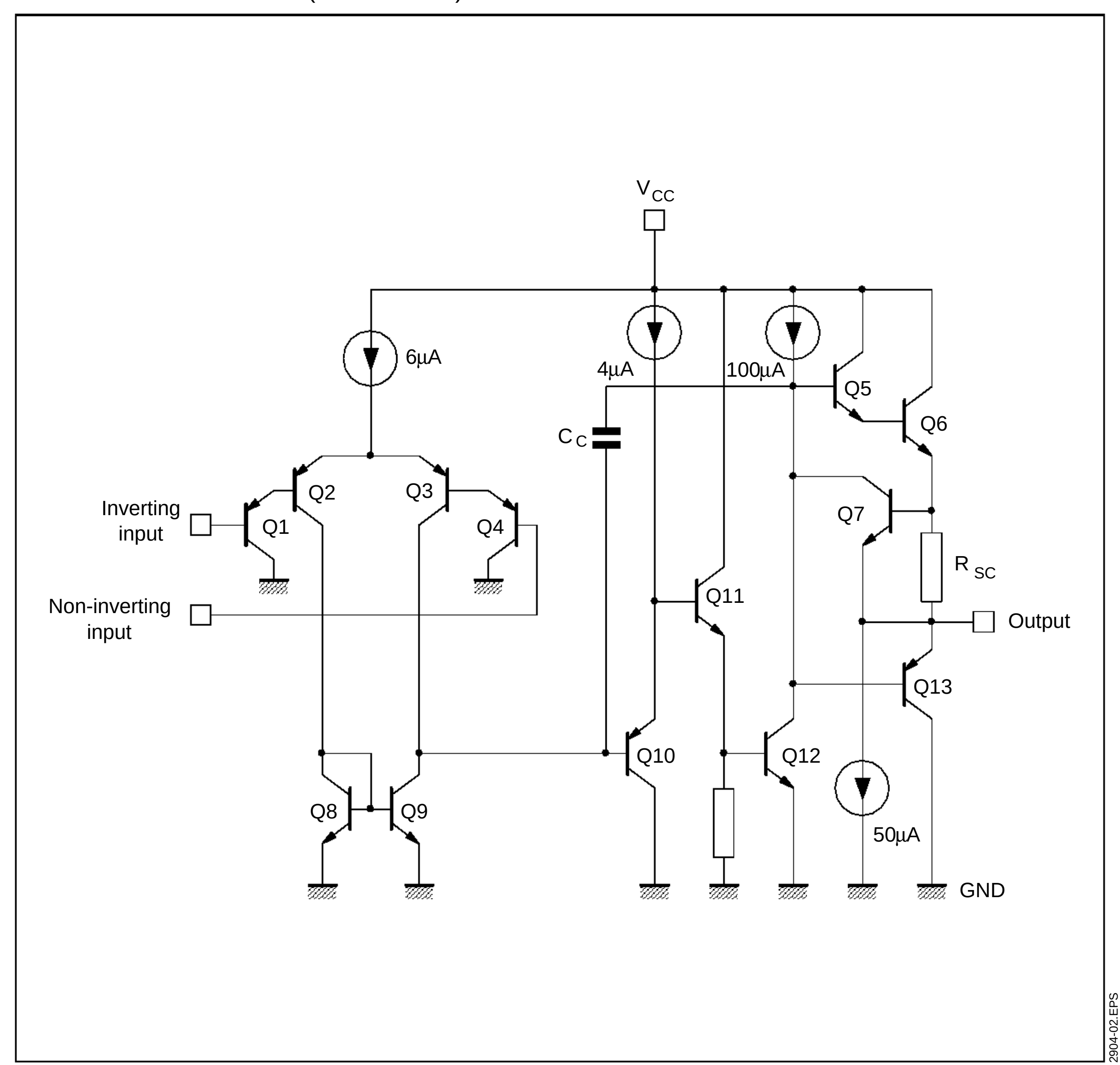
PIN CONNECTIONS (top views)



1 - Output 1
2 - Inverting input 1
3 - Non-inverting input 1
4 - V_{CC}^-
5 - Non-inverting input 2
6 - Inverting input 2
7 - Ouput 2
8 - V_{CC}^+

2904-01.EPS

SCHEMATIC DIAGRAM (1/2 LM2904)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	+32	V
V_i	Input Voltage	–0.3 to +32	V
V_{id}	Differential Input Voltage	+32	V
	Output Short-circuit Duration - (note 2)	Infinite	
P_{tot}	Power Dissipation	500	mW
I_{in}	Input Current - (note 1)	50	mA
T_{oper}	Operating Free-air Temperature Range	–40 to +125	^oC
T_{stg}	Storage Temperature Range	–65 to +150	^oC

2904-02.TBL

ELECTRICAL CHARACTERISTICS

V_{CC}^{+} = +5V, V_{CC}^{-} = Ground, V_O = 1.4V, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage - (note 3) T_{amb} = 25°C $T_{min.} \leq T_{amb} \leq T_{max.}$		2	7 9	mV
I_{io}	Input Offset Current T_{amb} = 25°C $T_{min.} \leq T_{amb} \leq T_{max.}$		2	30 40	nA
I_{ib}	Input Bias Current - (note 4) T_{amb} = 25°C $T_{min.} \leq T_{amb} \leq T_{max.}$		20	150 200	nA
A_{vd}	Large Signal Voltage Gain (V_{CC} = +15V, R_L = 2kΩ, V_O = 1.4V to 11.4V) T_{amb} = 25°C $T_{min.} \leq T_{amb} \leq T_{max.}$	50 25	100		V/mV
SVR	Supply Voltage Rejection Ratio (R_S = 10kΩ) (V_{CC}^{+} = 5 to 30V) T_{amb} = 25°C $T_{min.} \leq T_{amb} \leq T_{max.}$	65 65	100		dB
I_{CC}	Supply Current, all Amp, no Load V_{CC} = +5V, $T_{min.} \leq T_{amb} \leq T_{max.}$ V_{CC} = +30V, $T_{min.} \leq T_{amb} \leq T_{max.}$		0.7	1.2 2	mA
V_{icm}	Input Common Mode Voltage Range (V_{CC} = +30V) - (note 6) T_{amb} = 25°C $T_{min.} \leq T_{amb} \leq T_{max.}$	0 0		V_{CC}^{+}–1.5 V_{CC}^{+}–2	V
CMR	Common-mode Rejection Ratio (R_S = 10kΩ) T_{amb} = 25°C $T_{min.} \leq T_{amb} \leq T_{max.}$	70 60	85		dB
I_O	Output Short Circuit Current (V_{CC} = +15V, V_o = 2V, V_{id} = +1V)	20	40	60	mA
I_{sink}	Output Current Sink (V_{id} = -1V) V_{CC} = +15V, V_O = 2V V_{CC} = +15V, V_O = +0.2V	10 12	20 50		mA µA
V_{OPP}	Output Voltage Swing (R_L = 2kΩ) T_{amb} = 25°C $T_{min.} \leq T_{amb} \leq T_{max.}$	0 0		V_{CC}^{+}–1.5 V_{CC}^{+}–2	V
V_{OH}	High Level Output Voltage (V_{CC}^{+} = 30V) T_{amb} = 25°C R_L = 2kΩ $T_{min.} \leq T_{amb} \leq T_{max.}$ T_{amb} = 25°C R_L = 10kΩ $T_{min.} \leq T_{amb} \leq T_{max.}$	26 26 27 27	27 28		V
V_{OL}	Low Level Output Voltage (R_L = 10kΩ) T_{amb} = 25°C $T_{min.} \leq T_{amb} \leq T_{max.}$		5	20 20	mV
SR	Slew Rate (V_{CC} = 15V, V_I = 0.5 to 3V, R_L = 2kΩ, C_L = 100pF, T_{amb} = 25°C, unity gain)	0.3	0.6		V/µs
GBP	Gain Bandwidth Product (V_{CC} = 30V, f = 100kHz, T_{amb} = 25°C, V_{in} = 10mV, R_L = 2kΩ, C_L = 100pF)	0.7	1.1		MHz
THD	Total Harmonic Distortion (f = 1kHz, A_v = 20dB, R_L = 2kΩ, V_{CC} = 30V, C_L = 100pF, T_{amb} = 25°C, V_O = 2 $_{PP}$)		0.02		%

2904-03.TBL

ELECTRICAL CHARACTERISTICS (continued)

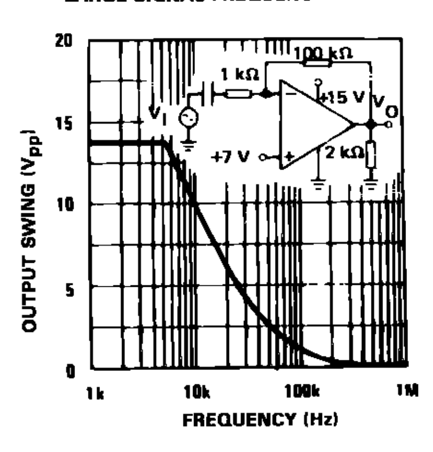
Symbol	Parameter	Min.	Typ.	Max.	Unit
DV_{io}	Input Offset Voltage Drift		7	30	μV/°C
DI_{io}	Input Offset Current Drift		10	300	pA/°C
V_{O1}/V_{O2}	Channel Separation (note 5) 1kHz ≤ f ≤ 20kHz		120		dB

2904-04.TBL

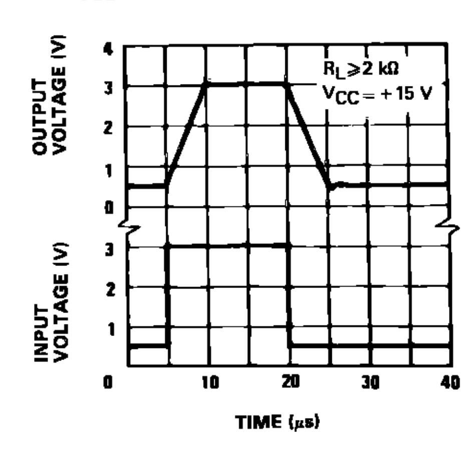
Notes :
1. This input current only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. This transistor action can cause the output voltages of the Op-amps to go to the V_{CC} voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output will set up again for input voltage higher than –0.3V.
2. Short-circuits from the output to V_{CC} can cause excessive heating if $V_{CC}^+ > 15V$. The maximum output current is approximatively 40mA independent of the magnitude of V_{CC}. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
3. $V_O = 1.4V$, $R_S = 0\Omega$, $5V < V_{CC}^+ < 30V$, $0 < V_{ic} < V_{CC}^+ - 1.5V$.
4. The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
5. Due to the proximity of external components insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequences.
6. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is $V_{CC}^+ - 1.5V$. But either or both inputs can go to +32V without damage.

OPEN LOOP FREQUENCY RESPONSE (Note 3)

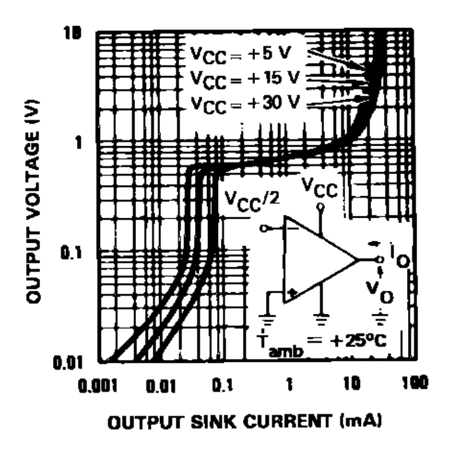
LARGE SIGNAL FREQUENCY RESPONSE



VOLTAGE FOLLOWER PULSE RESPONSE



OUTPUT CHARACTERISTICS



2904-03.EPS

VOLTAGE FOLLOWER PULSE RESPONSE (SMALL SIGNAL)

OUTPUT VOLTAGE (mV)

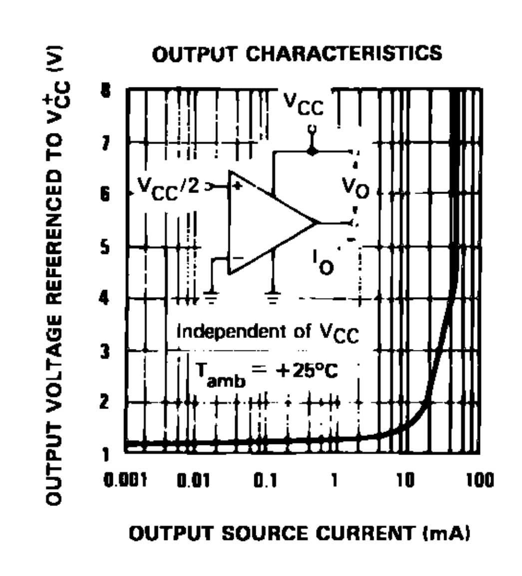
500
450
400
350
300
250

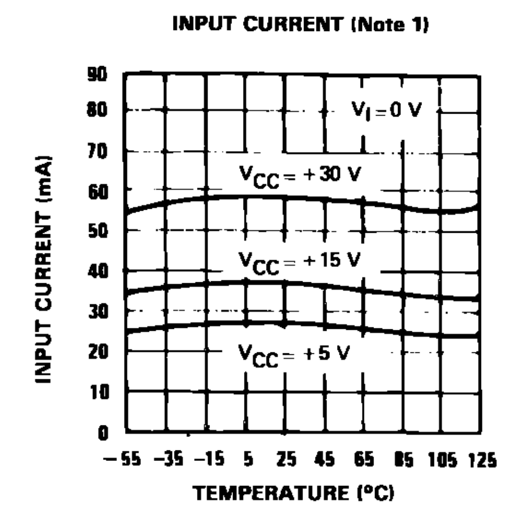
0 1 2 3 4 5 6 7 8

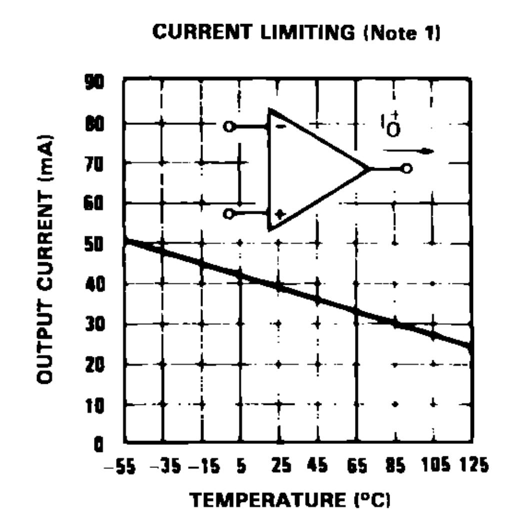
TIME (μs)

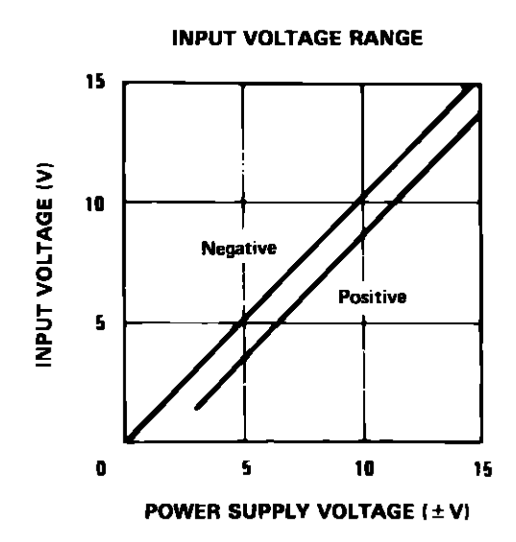
e_I e_O 50 pF Input Output

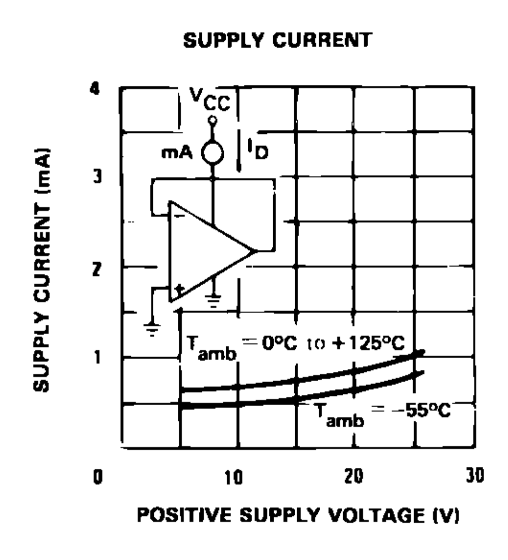
T_{amb} = +25°C
V_{CC} = +30 V



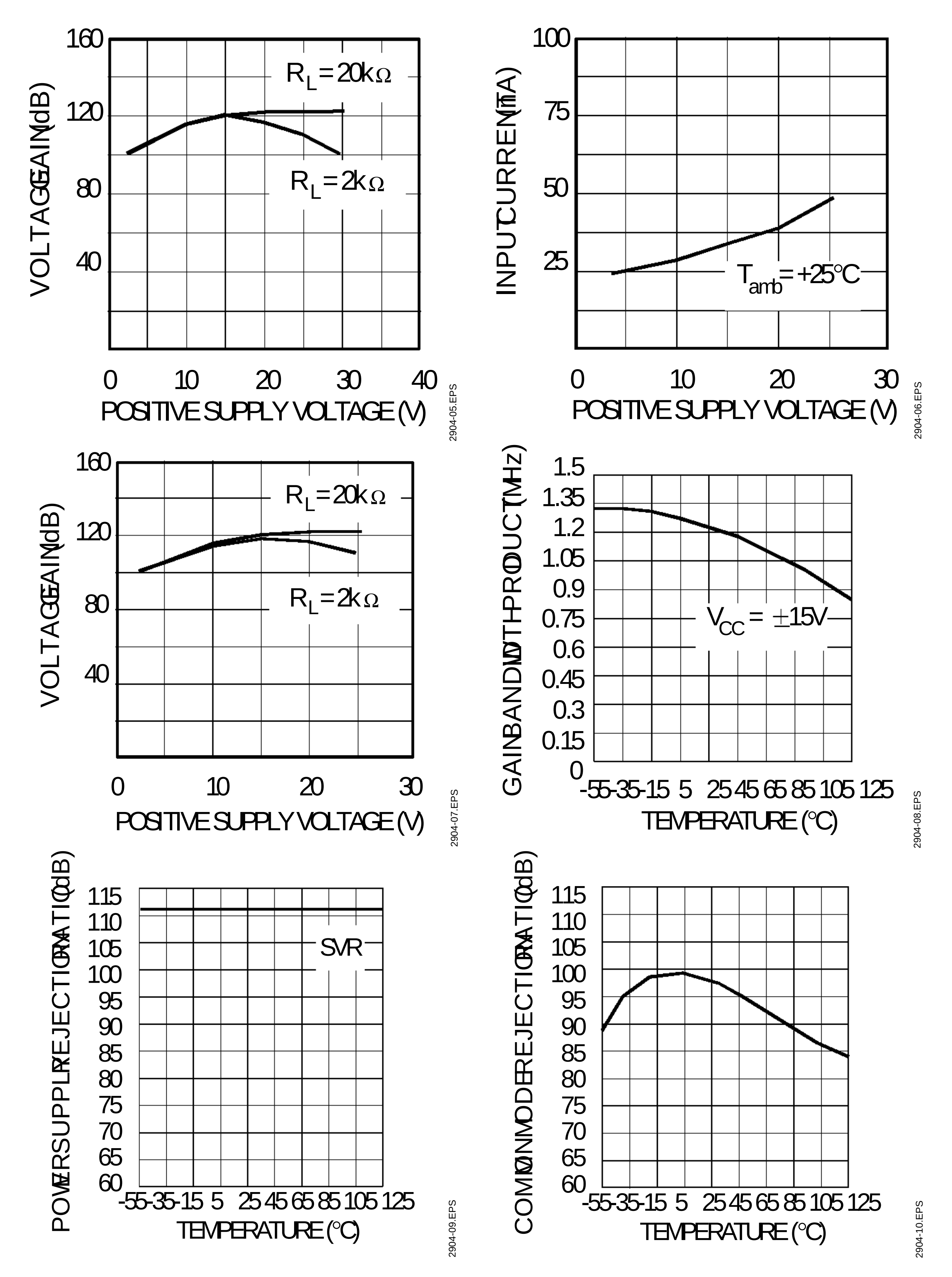








2904-04.EPS

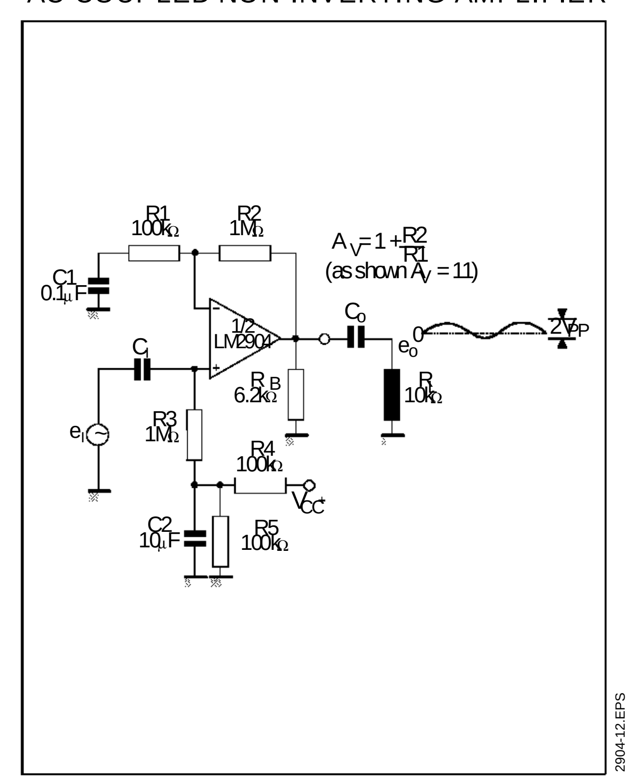

160
120
80
40
VOLTAGE GAIN (dB)
$R_L = 20k\Omega$
$R_L = 2k\Omega$
0 10 20 30 40
POSITIVE SUPPLY VOLTAGE (V)
2904-05.EPS
100
75
50
25
INPUT CURRENT (nA)
$T_{amb} = +25°C$
0 10 20 30
POSITIVE SUPPLY VOLTAGE (V)
2904-06.EPS
160
120
80
40
VOLTAGE GAIN (dB)
$R_L = 20k\Omega$
$R_L = 2k\Omega$
0 10 20 30
POSITIVE SUPPLY VOLTAGE (V)
2904-07.EPS
1.5
1.35
1.2
1.05
0.9
0.75
0.6
0.45
0.3
0.15
0
GAIN BANDWIDTH PRODUCT (MHz)
$V_{CC} = \pm15V$
-55 -35 -15 5 25 45 65 85 105 125
TEMPERATURE (°C)
2904-08.EPS
115
110
105
100
95
90
85
80
75
70
65
60
POWER SUPPLY REJECTION RATIO (dB)
SVR
-55 -35 -15 5 25 45 65 85 105 125
TEMPERATURE (°C)
2904-09.EPS
115
110
105
100
95
90
85
80
75
70
65
60
COMMON MODE REJECTION RATIO (dB)
-55 -35 -15 5 25 45 65 85 105 125
TEMPERATURE (°C)
2904-10.EPS

TYPICAL APPLICATIONS (single supply voltage) V_{CC} = +5V_{DC}

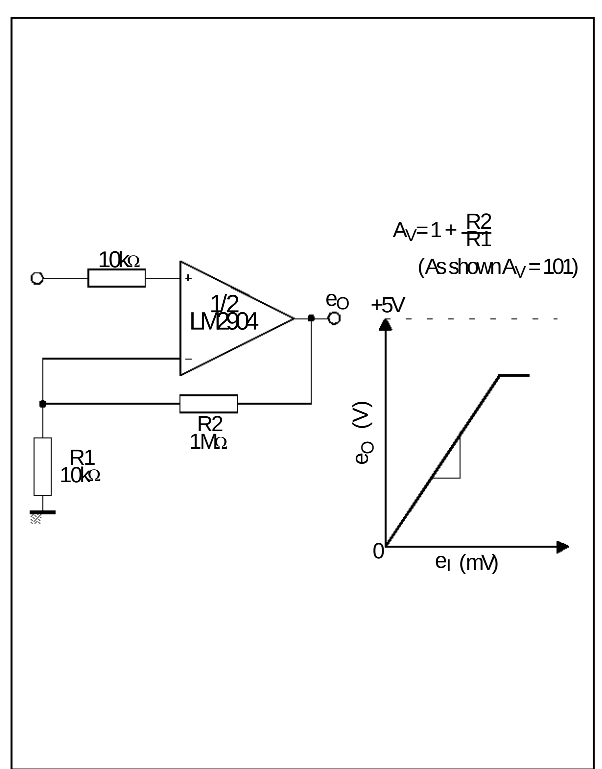
AC COUPLED INVERTING AMPLIFIER

Rf 100kΩ
$A_V = -\frac{R_f}{R1}$
(as shown A_V = -10)
CI
R1 10kΩ
1/2 LM2904
Co
eo
0
2VPP
RB 6.2kΩ
RL 10kΩ
eI
VCC
R2 100kΩ
R3 100kΩ
C1 10µF
2904-11.EPS

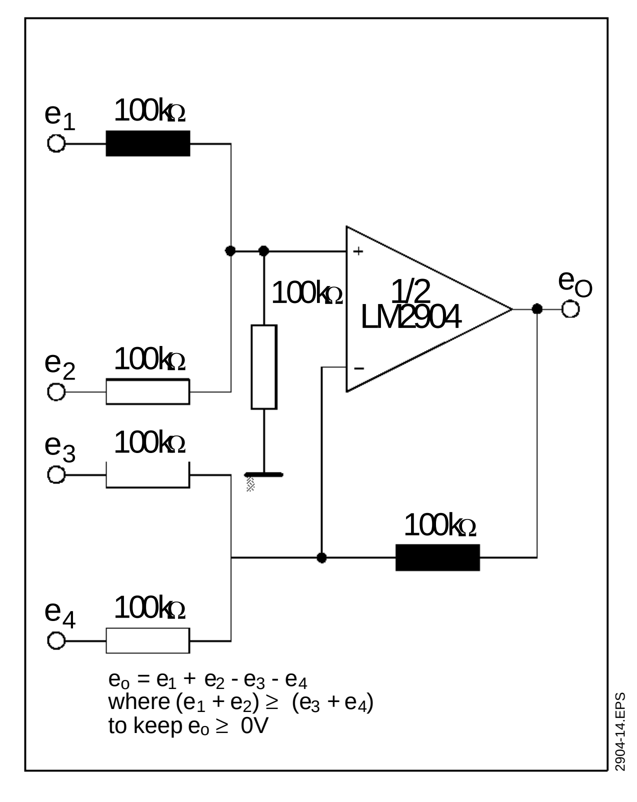
AC COUPLED NON-INVERTING AMPLIFIER



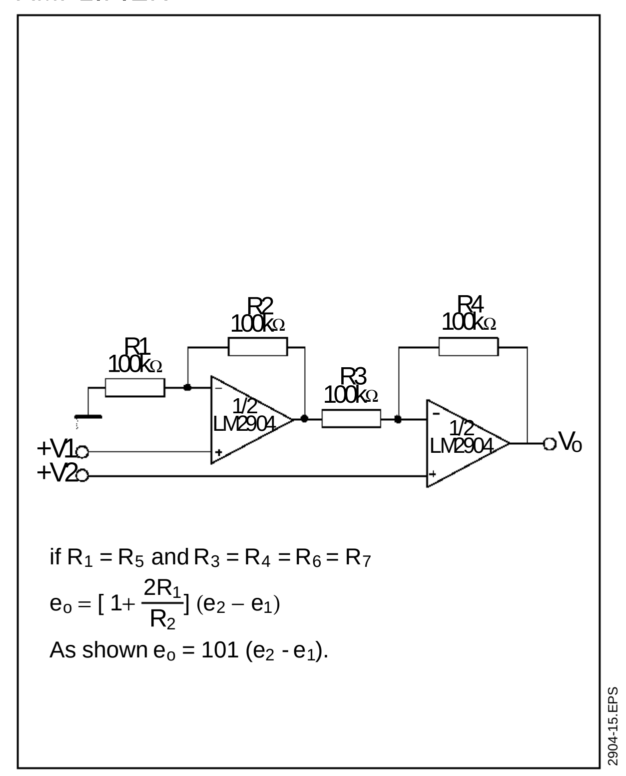
NON-INVERTING DC AMPLIFIER



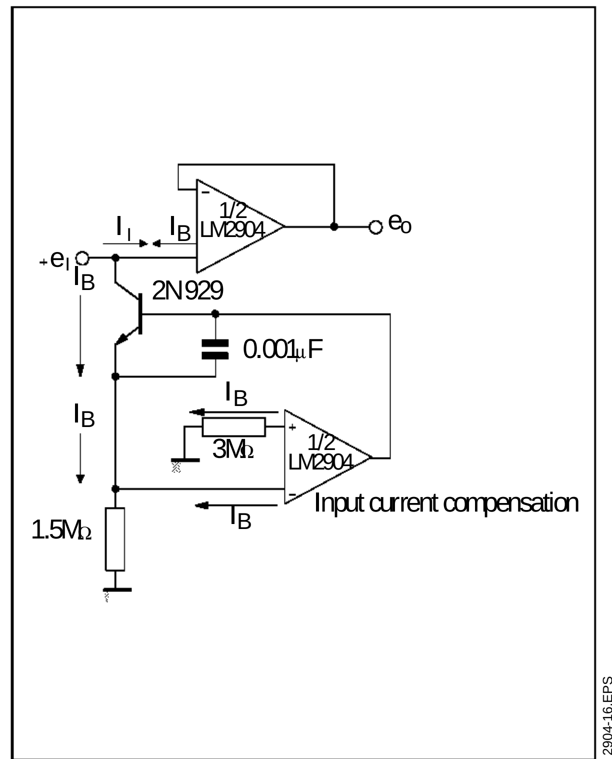
DC SUMMING AMPLIFIER



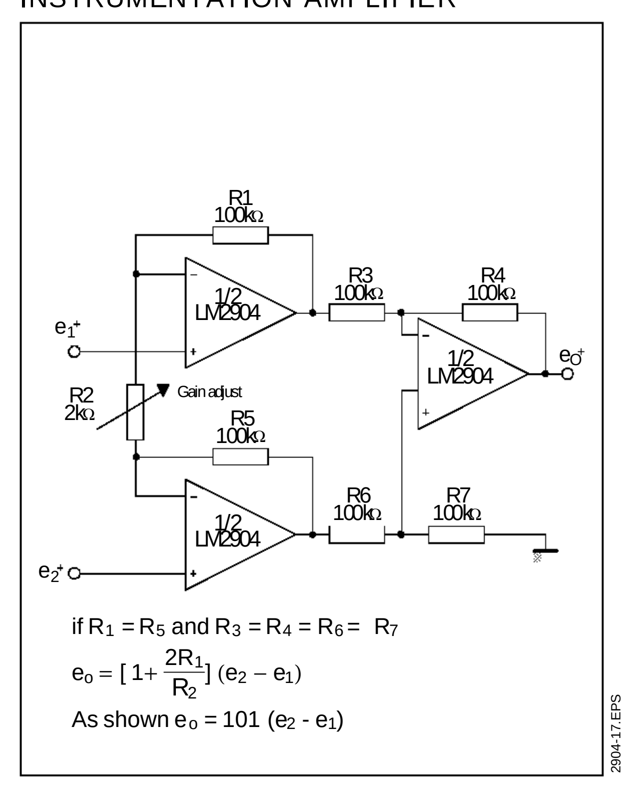
HIGH INPUT Z, DC DIFFERENTIAL AMPLIFIER



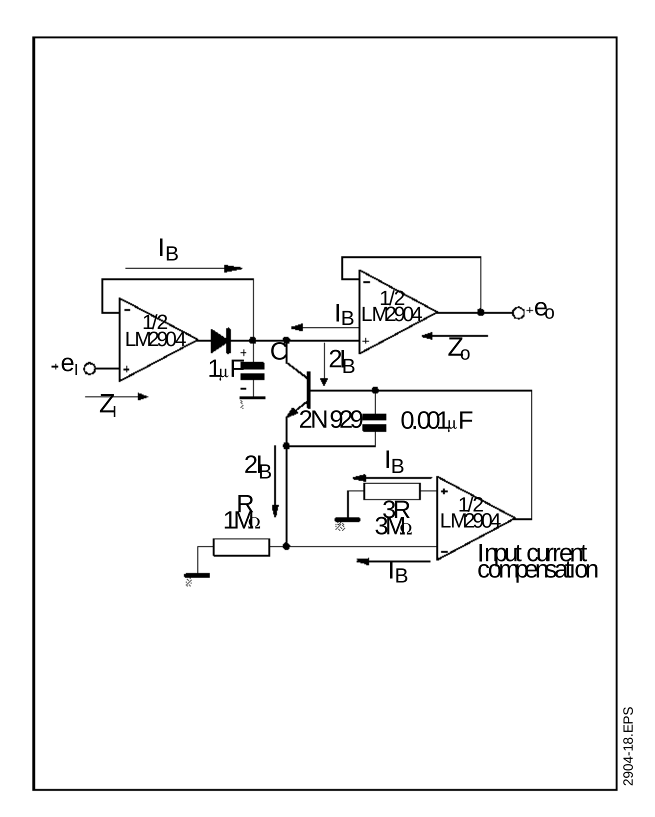
USING SYMMETRICAL AMPLIFIERS TO REDUCE INPUT CURRENT



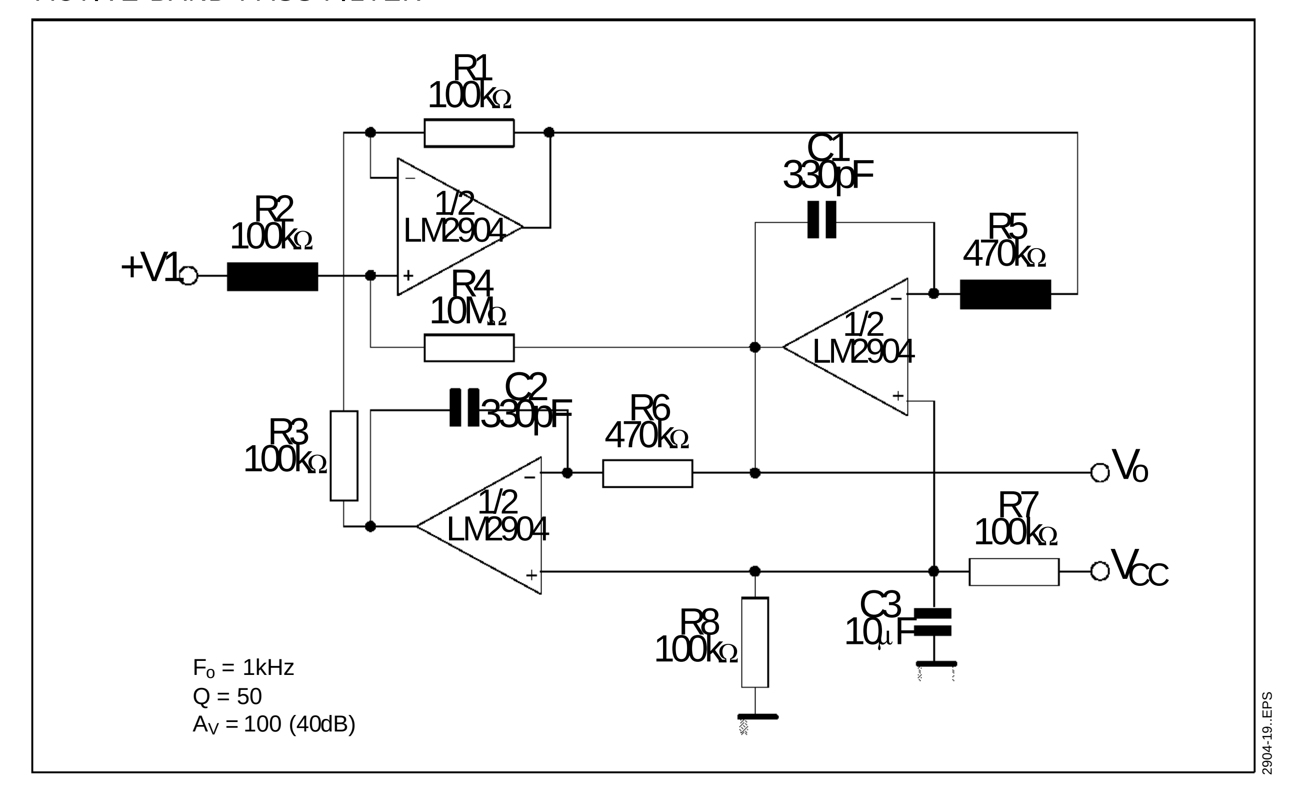
HIGH INPUT Z ADJUSTABLE GAIN DC INSTRUMENTATION AMPLIFIER



LOW DRIFT PEAK DETECTOR

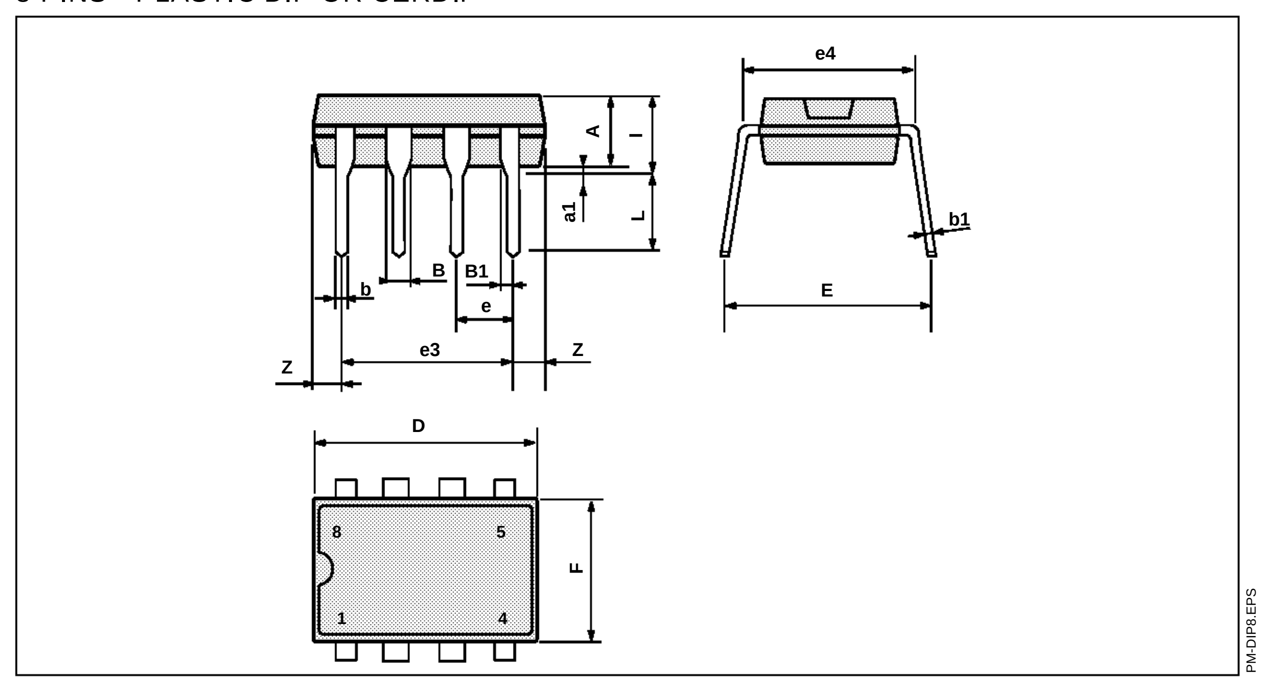


ACTIVE BAND-PASS FILTER



PACKAGE MECHANICAL DATA

8 PINS - PLASTIC DIP OR CERDIP



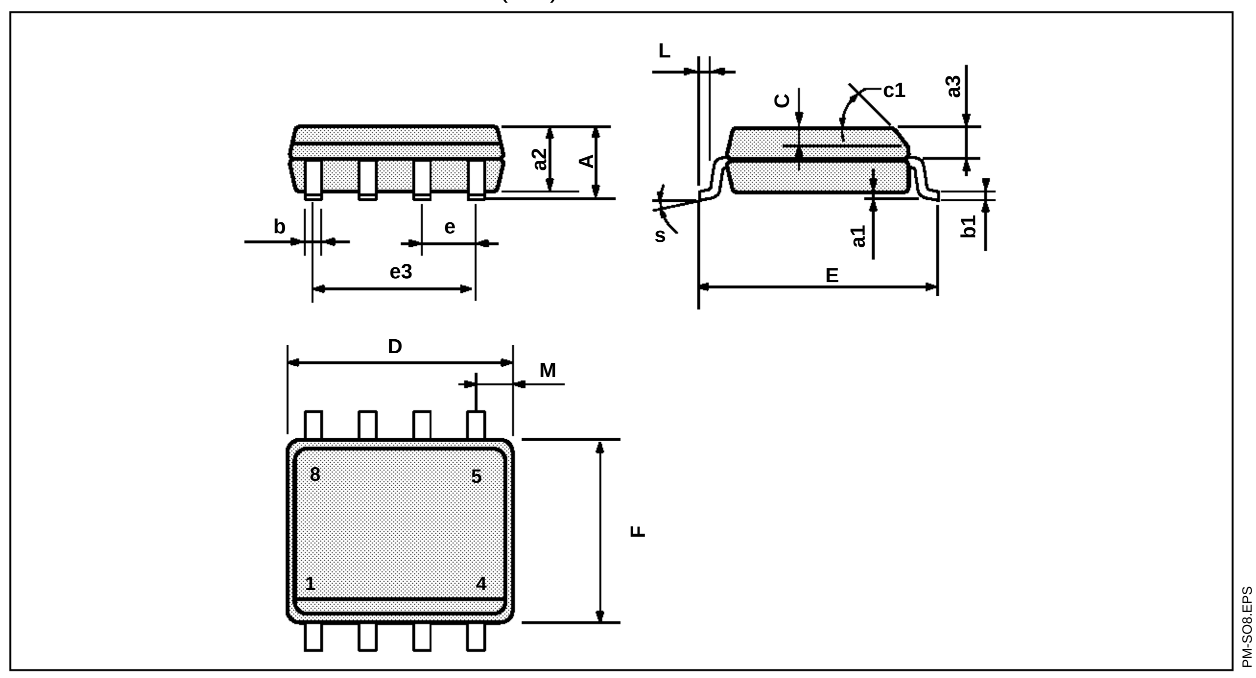
Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.32			0.131	
a1	0.51			0.020		
B	1.15		1.65	0.045		0.065
b	0.356		0.55	0.014		0.022
b1	0.204		0.304	0.008		0.012
D			10.92			0.430
E	7.95		9.75	0.313		0.384
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			6.6			0260
i			5.08			0.200
L	3.18		3.81	0.125		0.150
Z			1.52			0.060

DIP8.TBL



PACKAGE MECHANICAL DATA

8 PINS - PLASTIC MICROPACKAGE (SO)



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45^{o} (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		3.81			0.150	
F	3.8		4.0	0.150		0.157
L	0.4		1.27	0.016		0.050
M			0.6			0.024
S	8^{o} (max.)					

SO8.TBL